NOTES AND LITERATURE

ICHTHYOLOGY

Life History of the Eel.[1]—The waters of the northeastern Atlantic and of the adjacent North and Baltic Seas have been subjected in recent years to a most elaborate and continuous investigation, thanks to government subsidies and international cooperation. A coordinated study of the plankton and an investigation of the breeding habits and the young of the important food fishes and of their migrations and movements, have made up the large part of the ambitious program of this International Commission. In the allotment of the field it has fallen to the Danish Fisheries Bureau to undertake to complete our knowledge of the life-history of the common eel. Dr. Johs. Schmidt, with the aid of the Danish fisheries steamer *Thor* and Dr. Petersen's young-fish trawl, has added a new, and almost final, chapter in the solution of this mystery which has puzzled naturalists for centuries.

The suggestion of Dr. Theo. Gill in 1864 that the peculiar ribbon-like fish known as Leptocephalus was the larva of the Conger eel was subsequently verified by Dareste's (1874) anatomical comparisons and Delage's (1886) successful rearing of a Leptocephalus through its metamorphosis into the Conger eel. It remained for the Italian zoologists Grassi and Calandruccio to demonstrate in 1897 that the larva known as *Leptocephalus brevirostris* was in reality the young of the common European eel, *Anguilla vulgaris*. Their conclusions were based upon anatomical comparisons, transitional stages, and experimental rearing of the larval Leptocephalus to the young Anguilla. Most, if not all, of the material upon which the work of the Italian investigations were based was obtained at or near the Straits of Messina where the famous whirlpools bring to the surface the organisms of the deeper waters.

The eel fisheries of northern Europe are widespread and in places, especially in the Baltic Sea, they are extensive. There were in 1881, 18,491 eel traps in operation along the Swedish

[1] Contributions to the Life-History of the Eel (*Anguilla vulgaris* Turt.). By Johs. Schmidt. Conseil Perm. Intérnational pour Expl. de la Mer. Rapports et Proces-verbaux, Vol. 5, pp. 137–274, Pls. 7–13.

coast, and in 1900, 22,608 in Danish waters, excluding fresh water and the smaller areas of salt water. Yet in spite of these extensive fisheries and the wide distribution of the eel along the coasts of the Atlantic and its tributary waters in Europe, absolutely nothing has been known of the spawning grounds, or breeding habits of the eels of these more northern waters. Sexually mature eels have rarely, if ever, been taken. Dr. Schmidt records the discovery of but a single sexually mature male eel of the silver (migrating) type in shallow waters off the coast of Denmark. Leptocephalus larvæ belonging to the common eel (*L. brevirostris*) have never been taken, until recently, in the Atlantic. The specimen taken by the Challenger Expedition in the North Atlantic and referred by Günther to this species proves upon reexamination to belong to another species having 140 myomeres instead of the 111–118 characteristic of *L. brevirostris*.

In 1904 a single example of this latter species was captured by Dr. Schmidt in the tow nets of the *Thor* west of the Faeroes, and a few months later Dr. Holt, of the Irish Fisheries Bureau, took a second specimen west of Ireland. These captures gave the clue which Dr. Schmidt has most successfully followed. In the next two years Leptocephalus was discovered by Dr. Schmidt in large numbers in mid-summer to the west of the British Isles and France over depths of 1,000 meters. The transition stages between the hyaline pelagic larvæ in the Leptocephalus stage and the colorless "elvers" which have long been known along the northern and western coasts of Europe were also found by the *Thor* but at the close of summer and in the autumn. After a thoroughgoing investigation of these grounds and of the data regarding the movements and distribution of the young elvers along the coasts of Great Britain and continental Europe Dr. Schmidt comes to the following conclusions.

The common eel of northern Europe spawns in the Atlantic Ocean west of the British Isles and southward at least as far as the northern coast of Spain. The essential features of the spawning ground are (1) a depth of at least 1,000 meters and (2) a temperature at this depth above 7° C. This belt is a relatively narrow one along the edge of the continental shelf as it rises from the Atlantic basin. Leptocephalus larvæ have long been known in the Mediterranean and a much greater extension of the spawning grounds beyond the known limits to the south is not improbable. The Atlantic basin with its greater depths and lower temperatures appears to afford an effectual

barrier between the American and European eels (*Anguilla chryspa* and *A. vulgaris*). Eels of European streams approaching sexual maturity and migrating seaward must travel to the edge of the continental shelf to reach suitable spawning grounds. The Baltic and North Seas are too shallow, and waters to the west of Norway are deep enough but their temperatures are too low.

The eels, as they migrate, undergo a considerable change in appearance, passing from the stage known as the yellow eel to that of the silver eel, in which feeding is suspended, the digestive tract is shrunken and sexual glands show some enlargement. The direction of migration in the Baltic in the autumn is out toward the open sea. The paths of migration are usually parallel to the coast and in shallow water, though eels have been known to cross channels 60 meters in depth. The direction and rate of migration was worked out by Dr. C. G. Joh. Petersen, the director of the Danish Fisheries Laboratory, by means of marked fish. The rate of movement in the migratory season is about 15 kilometers per day. The eels in these shallow waters, where their presence is revealed by commercial fishing, are none of them sexually mature. Their further movements are unknown but the presumption is that they continue their course toward the open sea and to the edge of the continental shelf. A single capture in the English Channel twenty miles from land confirms this conjecture, as do also the captures made by Grassi and Calandruccio in the whirlpools at Messina, where occasional specimens of the common eel are brought to the surface, which differ materially from those taken in shallow waters. They are silver eels in which the breeding dress is further accentuated by darker color, the anterior border of the gill openings and the pectorals become an intense black, the eyes also become enormously enlarged and the sexual organs show greater maturity. Maturing eels have also been taken from the stomachs of the sword-fish and in the collection of Prince Albert of Monaco is a large eel taken from the stomach of the cachelot. These facts in conjunction with certain testimony on the part of fishermen suggest the possibility of a pelagic or bathypelagic habitat of the eel in its migration to the open sea.

The larvæ *Leptocephalus brevirostris* of the eel are true pelagic organisms, as is shown by their entire organization. Neither their structure nor their distribution indicates any relation to a bottom habitat. In life they are perfectly transparent

and are found in association with typically pelagic organisms such as Salpa, Cymbulia and Phronima, as well as the young of other pelagic or deep-sea fish, among which are five additional species of "Leptocephalus." They have also the leisurely movements characteristic of many pelagic animals.

The pre-Leptocephalus stages of the eel are as yet wholly unknown. The earliest season of investigation has been the month of May and at this time the pelagic larvæ are found during the day in greatest abundance in levels at a depth of about 100 m., but rise to the surface levels at night. This distribution of the youngest known stages leads Dr. Schmidt to surmise that the eggs of the common eel are bathypelagic, and that the larvæ as they develop rise to the upper levels.

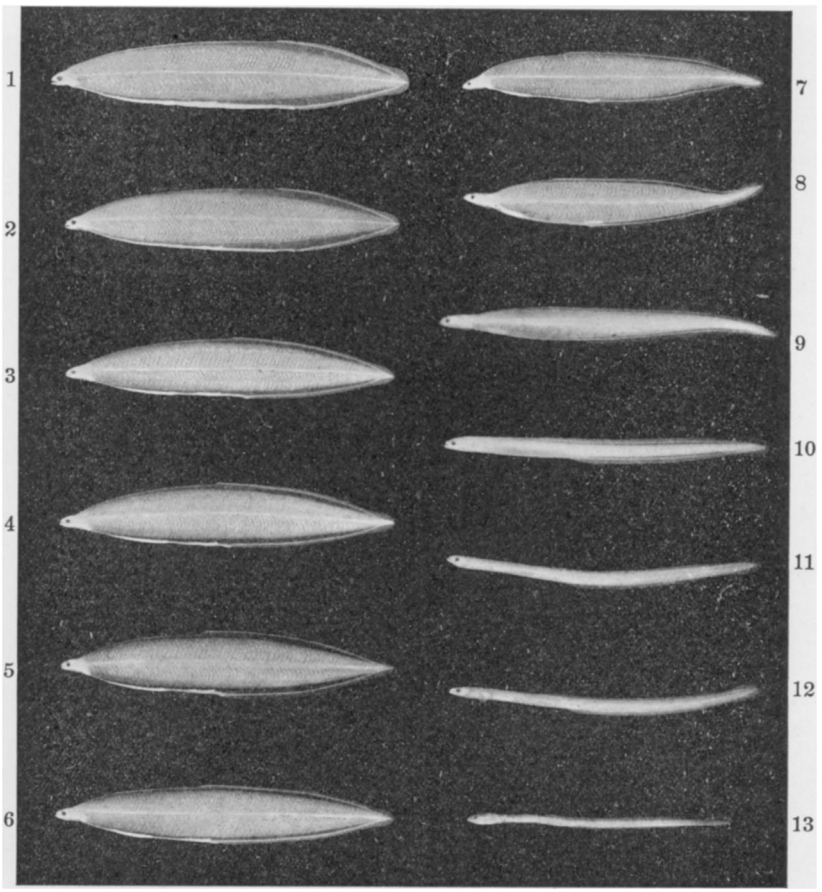
The pelagic larvæ appear to reach the height of the larval stage of development in June and cease active feeding, but do not as yet show the regressive phenomena which characterize the period of metamorphosis. They have also reached their maximum larval size 75 (60–88) mm. Both upper and lower jaws are equipped with long slender grasping teeth. No pigment is found in the body except in silvery iris of the eye. The digestive tract at this time extends through about two thirds of the length of the body.

The larval stage is followed by a long period of metamorphosis during which the form of the body changes from that of a colorless ribbon-like band to the pigmented cylindrical type with differentiated head and tail. The pelagic mode of life is abandoned and the young eels or elvers adopt the bottom habitat in shallow coastal and fresh waters into which they have migrated from the open sea. This period of metamorphosis occupies the entire year or more, during which no food is taken. The body gradually decreases in size as the metamorphosis proceeds, diminishing from an average length of 75 millimeters in the high seas in June to 65 millimeters a year later in coastal waters. The digestive tract shortens during this period from two thirds to one third of the total length of the body. Mandibular and vomerine teeth appear and dermal sense organs develop about the head.

During this long period of metamorphosis the Leptocephalus larvæ migrate slowly from their habitat above the 1,000-meter line shoreward. According to the recent summary of observations published by Professor Gilson, they reach the coasts of Spain and Ireland in October–December, and the western coasts

of France and England and the eastern shores of Scotland in January–February. In March the tiny elvers swarm along the shores of the Netherlands, Denmark and Norway and continue to arrive there during the month of May. Danish waters and the western Baltic form the eastern limits which the eel reaches in the elver stage. Their farther migrations into the Baltic and up the rivers of northern Europe are accomplished during the period of rapid growth which now ensues.

The extensive eel fisheries of Europe thus depend upon the migratory habit of a true Atlantic deep-water fish which seeks



Metamorphosis of the Eel (*Anguilla vulgaris*).
Figs. 1–2, 1st stage (*Leptocephalus brevirostris*). Figs. 3–6, 2d stage. Figs. 7–8, 3d stage. Figs. 9–10, 4th stage. Figs. 11–12, 5th stage. Fig. 13, 6th stage.

fresh-water streams and lakes for its period of growth but returns to the deep sea to spawn. CHARLES A. KOFOID.

The Valves in the Heart of Fishes.—The following note by Dr. H. D. Semor, of the College of Medicine in Syracuse University, New York, on the valves in the heart of fishes should be put on record.

It may be noted that in the so-called ganoid fishes there is more than one row of valves and from these ganoid fishes are derived the herring-like fishes. Some of these, as Dr. Senior has noted, have two rows of valves. Others have but a single one as in ordinary fishes.

"With regard to the question of teleosts having a conus arteriosus provided with more than one row of valves: In addition to Albula[1] which has long been known to have two rows, I have found a conus with two rows of valves (each row having two cusps) in *Tarpon atlanticus*,[2] *Megalops cyprinoides*,[3] and in *Pterothrissus gissu*.[4] I think this list will prove to be complete, as I have examined, with a negative result, Elops,[2] Chirocentrus,[5] Chanos,[3] Dorsosoma,[2] Notopterus,[2] Pomolobus,[5] Alosa,[5] Brevoortia,[5] and Boas has examined Osteoglossum.[6]

"A well-marked or vestigial conus arteriosus with *one* row of valves only, occurs in Elops,[4] Hyodon,[5] Chirocentrus,[5] Chanos,[3] Notopterus,[6] Osteoglossum[6] and Dorosoma.[2] That it also occurs in other allied genera, I have little doubt. When I collect enough specimens, I intend to describe and figure the conus (or vestige) in a sufficient number to indicate its mode of disappearance." DAVID S. JORDAN.

PARASITOLOGY

The Hereditary Transmission of Germ Diseases.—The earlier views which favored hereditary transmission of germ diseases have been subjected for nearly half a century to careful scrutiny at the hands of bacteriologists and are now generally rejected. Experimental evidence has been furnished from many quarters that the supposed cases are due to a contamination of the offspring during transit through the maternal passages at birth, or

[1] Stannius. Bemerkungen über das Verhaltniss der Ganoiden zu den Clupeiden, insbesondere zu Butirinus Rostock, 1846. Boaz. *Morph. Jahrb.*, Bd. 6, p. 527.

[2] Senior. *Biol. Bull.*, Vol. XII, p. 146.

[3] Senior. *Biol. Bull.*, Vol. XII, p. 378.

[4] Senior. *Anatomical Record*, Vol. 1, No. 4, p. 82. (*Am. J. of Anatomy*, Vol. VI, No. 4.)

[5] My own notes, unpublished.

[6] Boaz. *Morph. Jahrb.*, Bd. 6, p. 527.